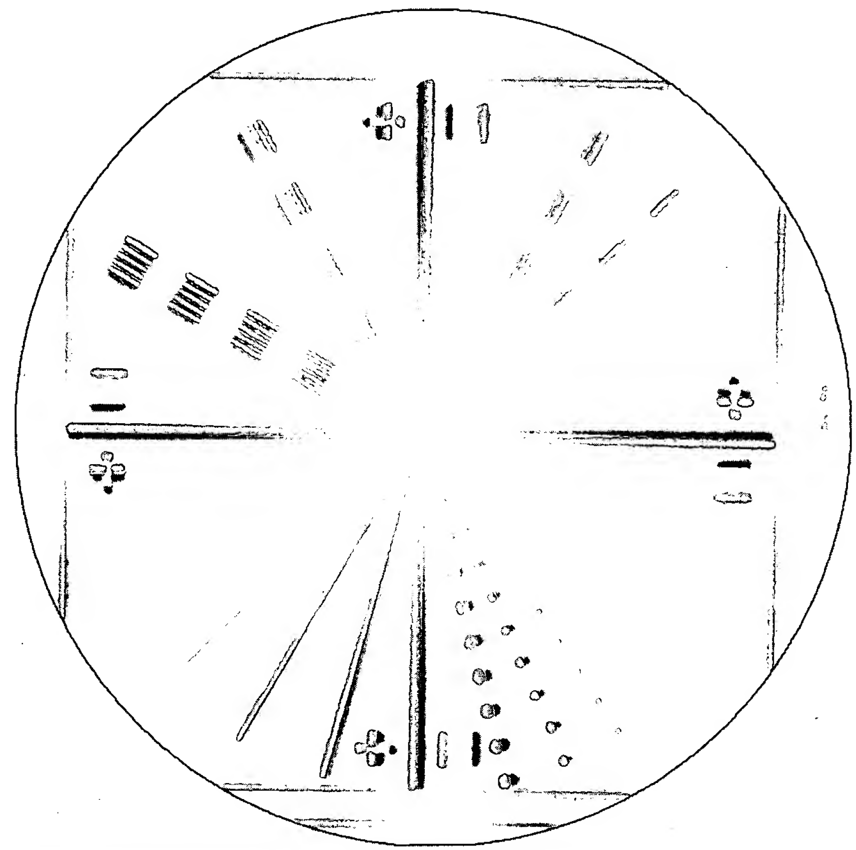
CPD Scanning Overview

Contact Potential Difference Scanning for Surface Measurements

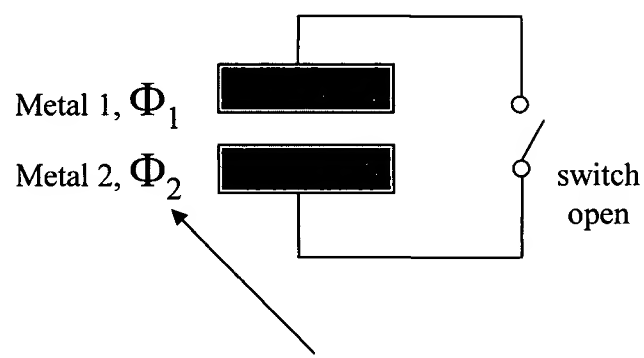
Unique Sensor for Imaging of Geometry and Chemistry

- High-speed, non-contact, non-destructive detection of surface chemistry and geometry.
- High resolution imaging at speeds suitable for real-time process control.
- Adaptable to a variety of configurations and applications.



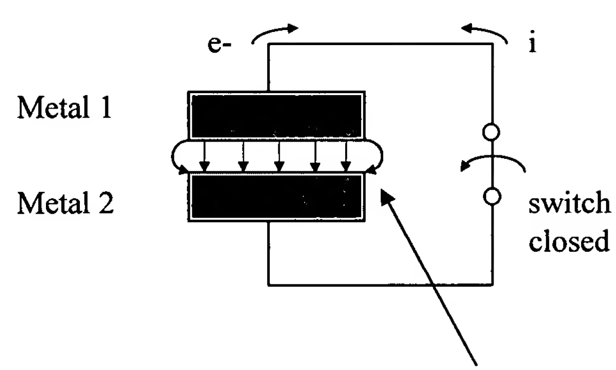
Theoretical Concept of Contact Potential Difference

Contact Potential Difference (CPD) is the difference in surface potential that is created when two dissimilar materials (e.g. metals) are electrically connected.



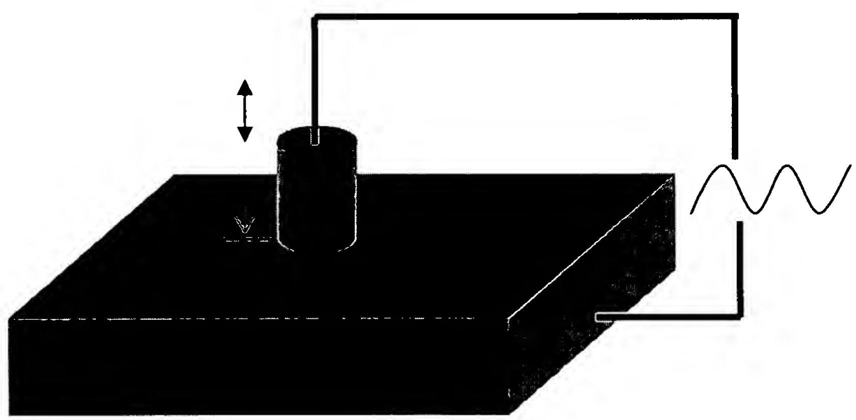
Surface Potential: prevents electrons from 'spilling' out of the bulk.

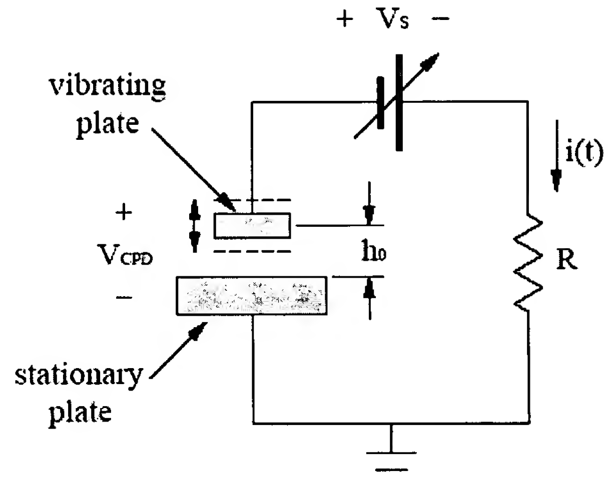
Electrons flow to equilibrate their energies.



Electrical field develops when the switch is closed

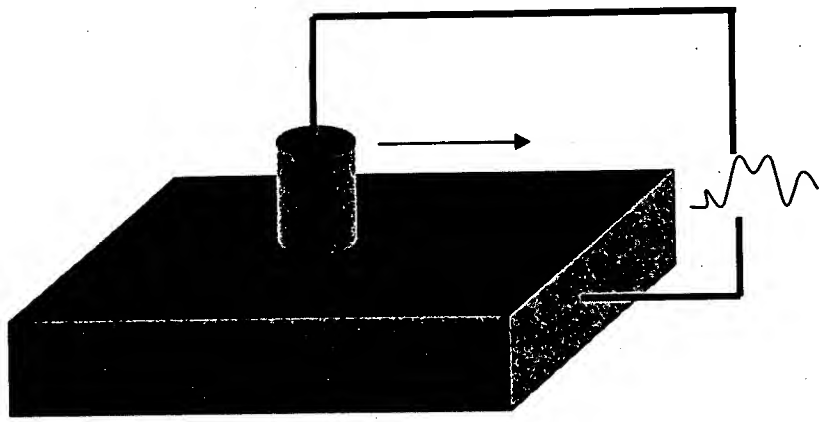
Prior Technology: Vibrating Kelvin Probe

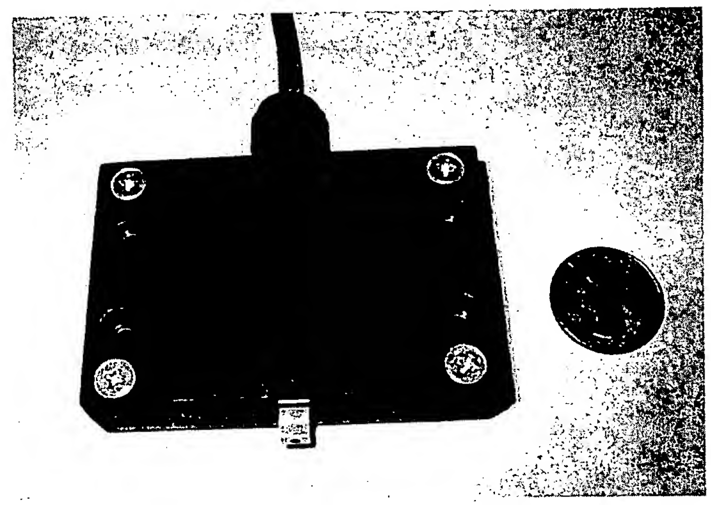


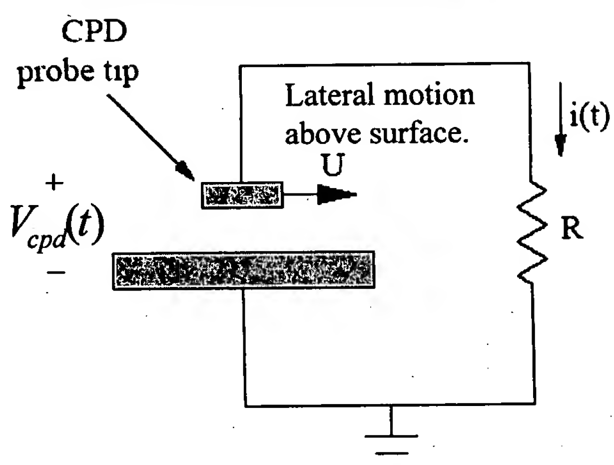


$$i(t) = (V_{CPD} - V_S)\frac{dC}{dt}$$

Scanning CPD Sensor

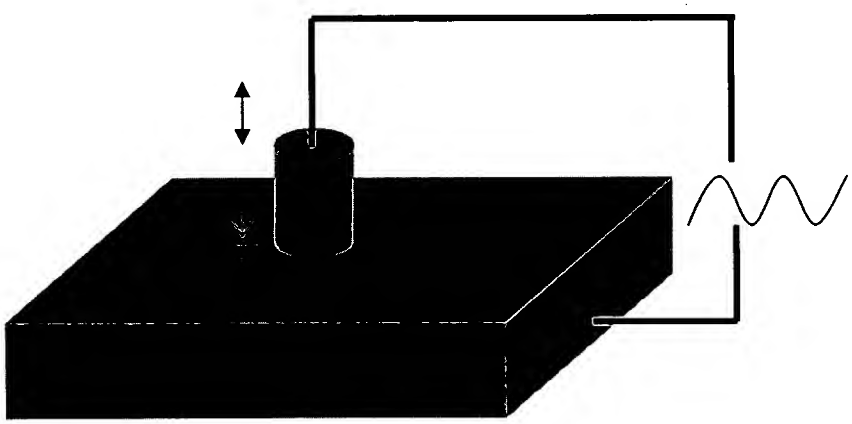






$$i(t) = V_{cpd}\frac{dC}{dt} + C\frac{dV_{cpd}}{dt}$$

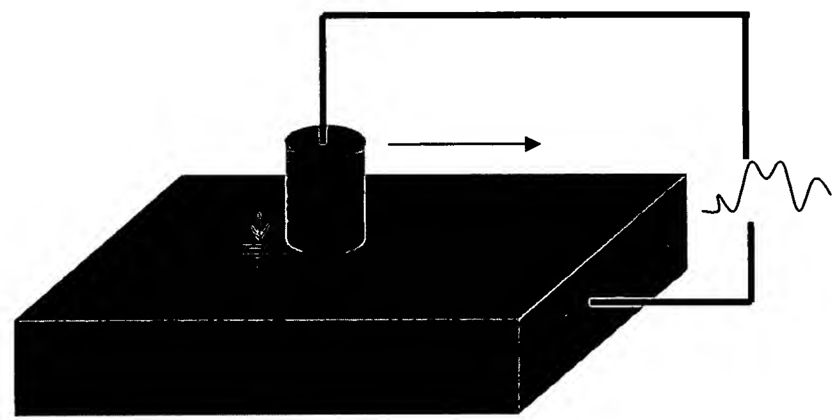
Vibrating vs. Scanning



Vibrating Probe – Old Technology

Vertical motion (vibration) of the probe produces a time-varying signal at a single location on the surface.

- *Slow data acquisition*
- *Mechanically and electronically complex*
- *Measures only metallic surfaces*

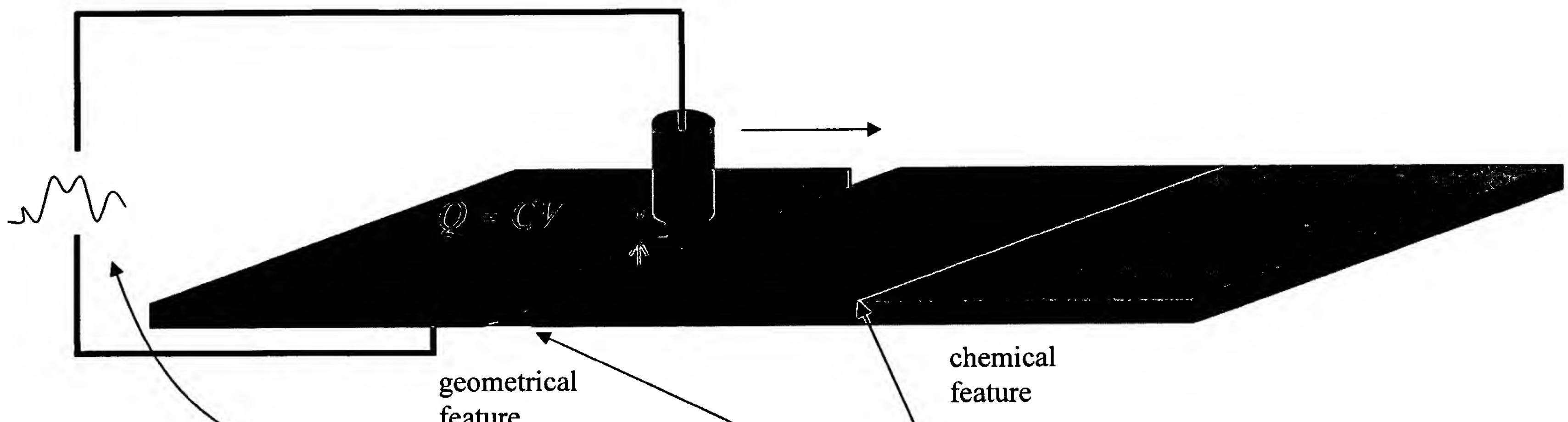


Scanning Probe – New *CPD* Technology

Motion (scanning) of the probe produces a continuous stream of data along the direction of motion.

- *Fast data acquisition*
- *Mechanically and electronically simple*
- *Measures dielectric layers and interfaces*

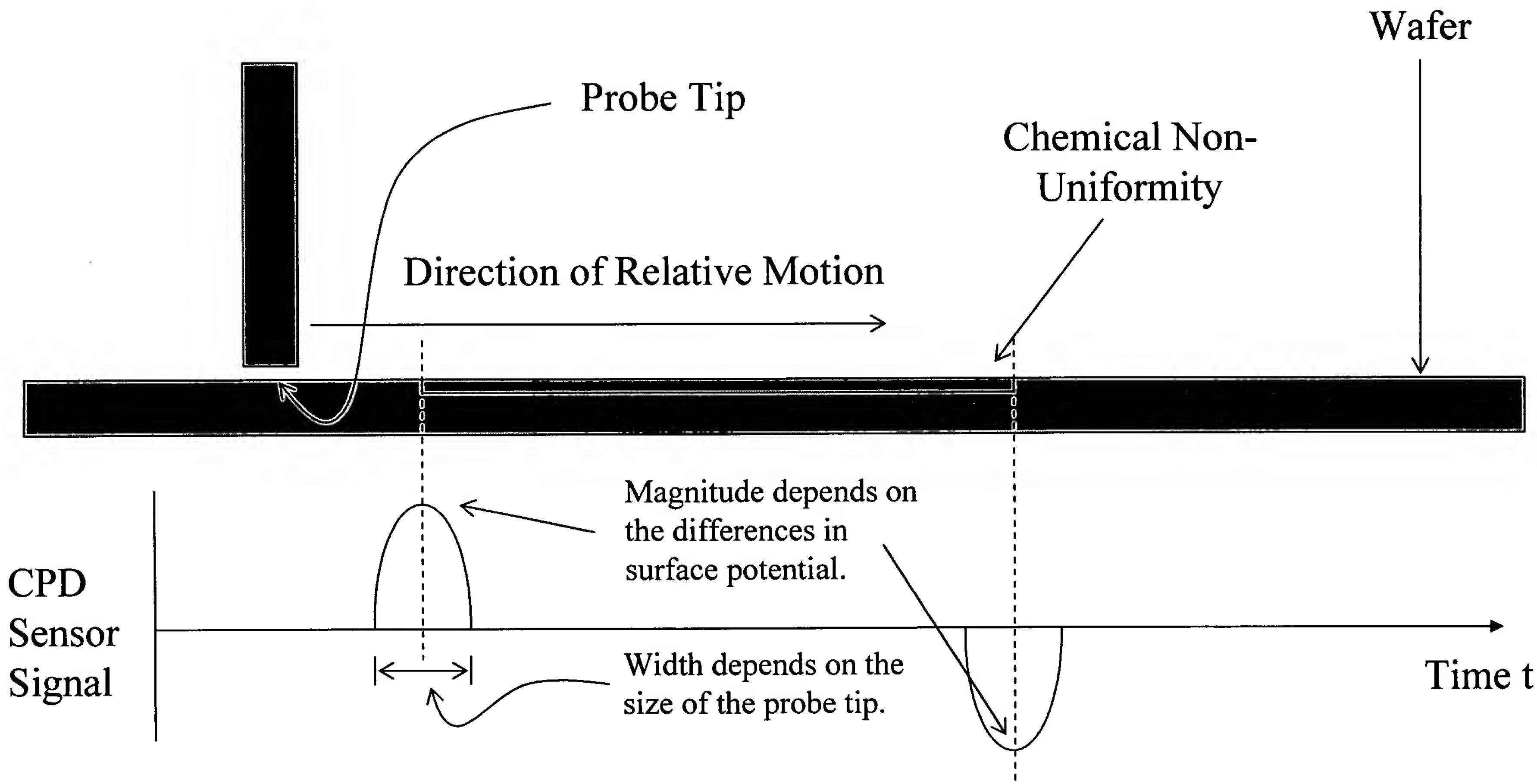
CPD Scanning Over Geometric and/or Chemical Features



$$i(t) = V\frac{dC}{dt} + C\frac{dV}{dt}$$

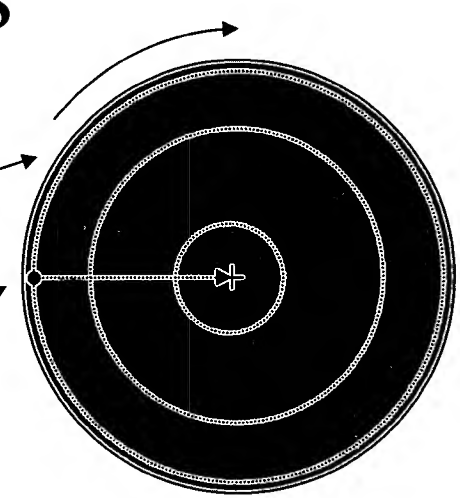
- Geometric changes across the surface result in changes in capacitance (dC/dt).
- Surface potential (chemistry) changes across the surface result in changes in voltage (dV/dt).
- The sensor produces a signal that is a combination of geometric and surface potential changes across the surface.

Differential CPD Signal



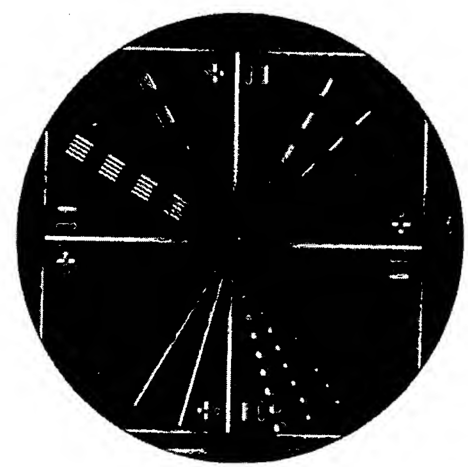
Example of Scanning Method – Flat Surfaces

Sample is mounted on vacuum chuck and spindle, and rotated at up to 5000 rpm to create relative motion between sensor and wafer surface.



The probe tip steps along a radius of the wafer, acquiring concentric circles, or “tracks”, of data.

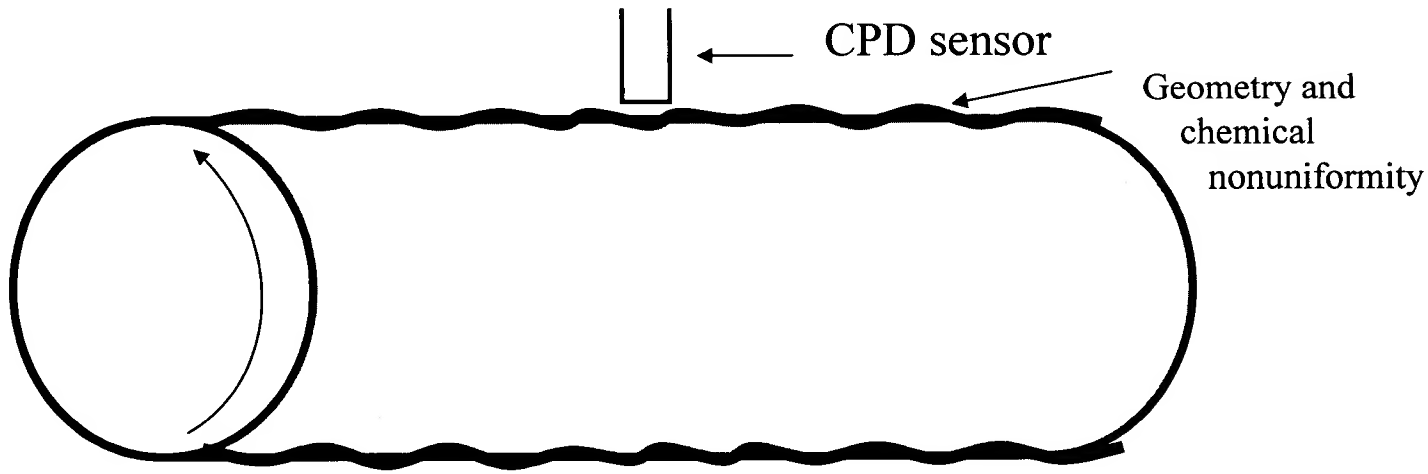
The resulting radial data is displayed as an image representing samples of the voltage output of the sensor.

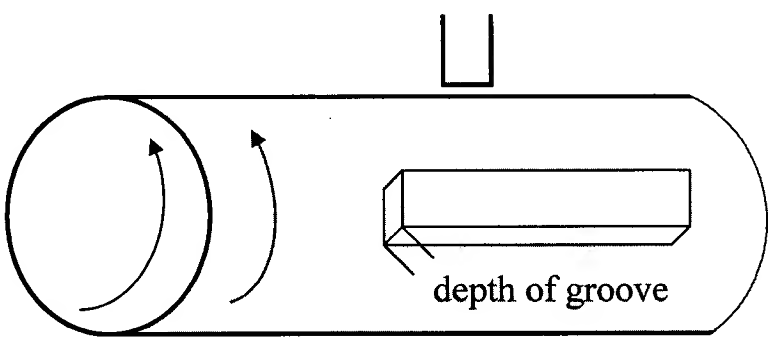


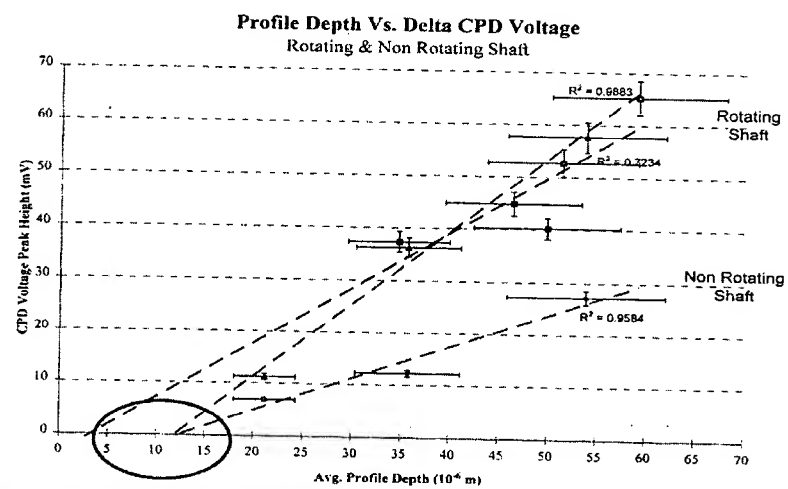
Patterned Silicon Wafer

Example of a Scanning Method – Cylindrical Surfaces

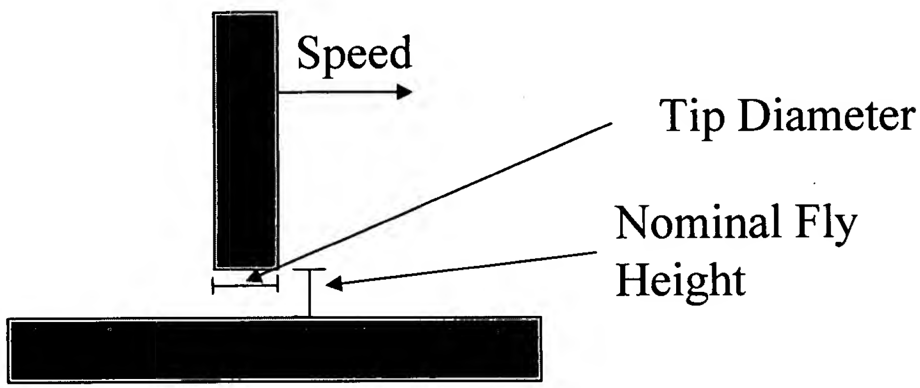
shaft







Scanning Variables



Variable	Typical Values	Smaller	Larger
Tip Diameter	25 μm to 500 μm	Improved resolution	Increased signal strength
Nominal Fly Height	15 μm to 100 μm	Improved resolution and increased signal strength	Less probability of wafer contact
Speed	250 rpm to 1000 rpm	Better resolution	Faster scanning speed and increased signal strength
Averaging	1 to 10	Faster scanning speed	Increased signal-to-noise
Samples / Track	1000 to 40,000	Less data for display and processing	Required for improved resolution

Important Technical Detail

$$i = C\,\frac{dV}{dt} + V\,\frac{dc}{dt}$$

$$dV \;\rightarrow\; \frac{dV}{dx}\cdot\underbrace{\frac{dx}{dt}}_{\text{velocity}}$$

$$i = \upsilon\left[c\,\frac{dV}{dx} + V\,\frac{dc}{dx}\right]$$

signal gets
better as
velocity (speed)
increases

spatial
variation of
V and C